

Book Review

KARLSTROM, THOR N. V. & BALL, GEORGE B. (editors). 1969. The Kodiak Refugium: Its Geology, Flora, Fauna, and History. Ryerson Press, Toronto, for The Boreal Institute, University of Alberta, xvi + 262 p., 1 plate, 28 figs. \$10.00.

One of the authors contributing to this small book notes that it is not often that refugia are first proposed on geological grounds alone; yet this is the case with the small area of southwest Kodiak Island which was ice free during the last two glaciations of the island. The book shows that the ice free area served as a biotic refugium.

Carl Lindroth, discusses in one of the early chapters the different types of Pleistocene refugia and the history of the concept of refugia. Later he contributes chapters on the carabid beetles of the Kodiak refugium and a summary of the conclusions of all of the contributing authors. Another paper by George Ball discusses in detail the probability of survival and evolution of a subgenus *Cryobius* of carabid beetles in the Kodiak refugium. Eric Hultén deals with the implications of the distributions of higher vascular plants, but his chapter also includes much information on the flora of all of Kodiak Island. Other papers contribute less information concerning the Pleistocene biota of the refugium, but like Hultén's paper are of value because they document the present biota. H. Persson's chapter on the Kodiak bryophytes and D. K. Hilliard's chapter on the Chrysophyceae are of this sort. In another chapter, Ball and Lindroth using the taxonomic determinations of numerous specialists, provide a list of the invertebrates collected in the refugium and detailed information on collecting localities. Vertebrates of Kodiak Island are discussed by J. D. McPhail, dealing with fishes, and R. L. Rausch, dealing with mammals. A lengthy chapter by Thor Karlstrom outlines the geological basis for the Kodiak refugium.

Because their distribution and ecology are relatively well known, carabid beetles and the higher plants provide the best evidence for the survival of a terrestrial biota in the Pleistocene Kodiak refugium. Ball and Lindroth show that the fauna of the refugium includes flightless carabid beetles adapted to alpine (arctic) environments. Presently these insects are restricted to the alpine areas of the refugium, but during the glaciation of Kodiak Island, they probably occupied lowland sites. Hultén's data for plants is of a similar nature.

Karlstrom suggests that faunal exchange between Kodiak and the mainland could have occurred either in the Sangamon interglacial or during a mid-Wisconsin "interglacial." The alpine (arctic) adapted beetles which survived glaciation of the island in the refugium are thought by Ball to have immigrated during the Sangamon interglacial. But world-wide evidence shows that interglacial climates were as mild or milder than the present. Lowland habitats of Kodiak Island and the adjacent mainland would have been similar to those of today or perhaps even forested. I find it difficult to believe that flightless alpine (arctic) carabid beetles could have moved through such habitats to Kodiak Island. The waters separating Kodiak Island from the mainland would have posed another formidable barrier for certain elements of the present fauna. Ball assumes that there must have been an interglacial land connection, but higher sea levels concomitant with an interglacial would enlarge rather than diminish the sea barrier.

None of the authors have dealt explicitly with this dilemma, even though the explanation is rather obvious. The alpine beetles now found in the Kodiak refugium could have invaded

the island during a glacial advance from an ice marginal refugium on the now submerged continental shelf. Lowered sea levels during major glaciations and submerged linear features on the continental shelf near Kodiak (interpreted as moraines by Karlstrom) make this suggestion highly probable. An ice marginal area would by definition possess a periglacial climate suitable for occupation by arctic and alpine adapted species of beetles. At some time during the advance of glaciers on Kodiak Island and the nearby Alaska Peninsula or perhaps during an interstadial, the continental shelf refugium could have extended from the inner Aleutian Islands to southwest Kodiak Island. This seems to be the logical explanation for the strong Aleutian affinities of the Kodiak refugium fauna as noted by Lindroth. Further glacial advances isolated the Kodiak refugium and probably obliterated large areas of the shelf refugium.

In as much as sea levels were 60 feet lower than at present as late as 8000 years ago, the continental shelf areas may have also been important for the postglacial colonization of the island.

It is unfortunate that Karlstrom did not explore some of these possibilities. Bathymetric maps of the areas near Kodiak, and the Alaska and Kenai Peninsulas, or diagrams indicating the probable extent of unglaciated, emerged continental shelf under various hypothetical combinations of glaciation and sea level would have been much more pertinent to the theme of this book than world wide correlation charts (p. 37) or the table listing data for a Potassium Argon analysis of the granitic intrusives of the island (p. 28).

The ages of the last two glaciations of the island are critical since it was during these events that the refugium was large enough to support a terrestrial biota. It is unfortunate that Karlstrom has no C^{14} dates to substantiate his claim that both are of Wisconsin age. His correlation of a marine unit separating the drifts of the last two glaciations on the island with the mid-Wisconsin Woronzofian sediments in the Cook Inlet may be incorrect since the Woronzofian sediments have reached their present position as a result of tectonism, a process that Karlstrom feels was not important near the refugium. Correlation of the interval between the Ikpik and Olga Bay advances of the last (Akalura) glaciation on Kodiak Island with the Two Creeks oscillation of Northern Europe (p. 34) is unjustified. I feel that such correlations must be based on C^{14} dated sedimentary sequences. As noted above, the Kodiak sequence is totally lacking in C^{14} dates.

Finally I object to Karlstrom's use of the term interglacial for the climatic oscillation represented by the Woronzofian transgression. Most geologists consider this world wide event to be an interstadial. Moreover, foraminifera from the Woronzofian sediments in the Cook Inlet area show that water temperatures were colder than at present, a conclusion consistent with interstadial rather than interglacial conditions.

My only technical complaint about this book is that the map showing the distributions of moraines surrounding the refugium is practically illegible. Otherwise I think it very fortunate that all of these papers could be printed in one volume. But I hope that the book is not considered to be the final statement on the Kodiak refugium. Hultén rightly suggests the need for pollen analytical studies. In addition a comparison of soil development and weathering in the refugium and other glaciated areas of the island would be interesting. I have already stated the need for more detailed geological investigations.